Georgia Tech Air Transportation Laboratory

ATL 1.5 Metering Scheme

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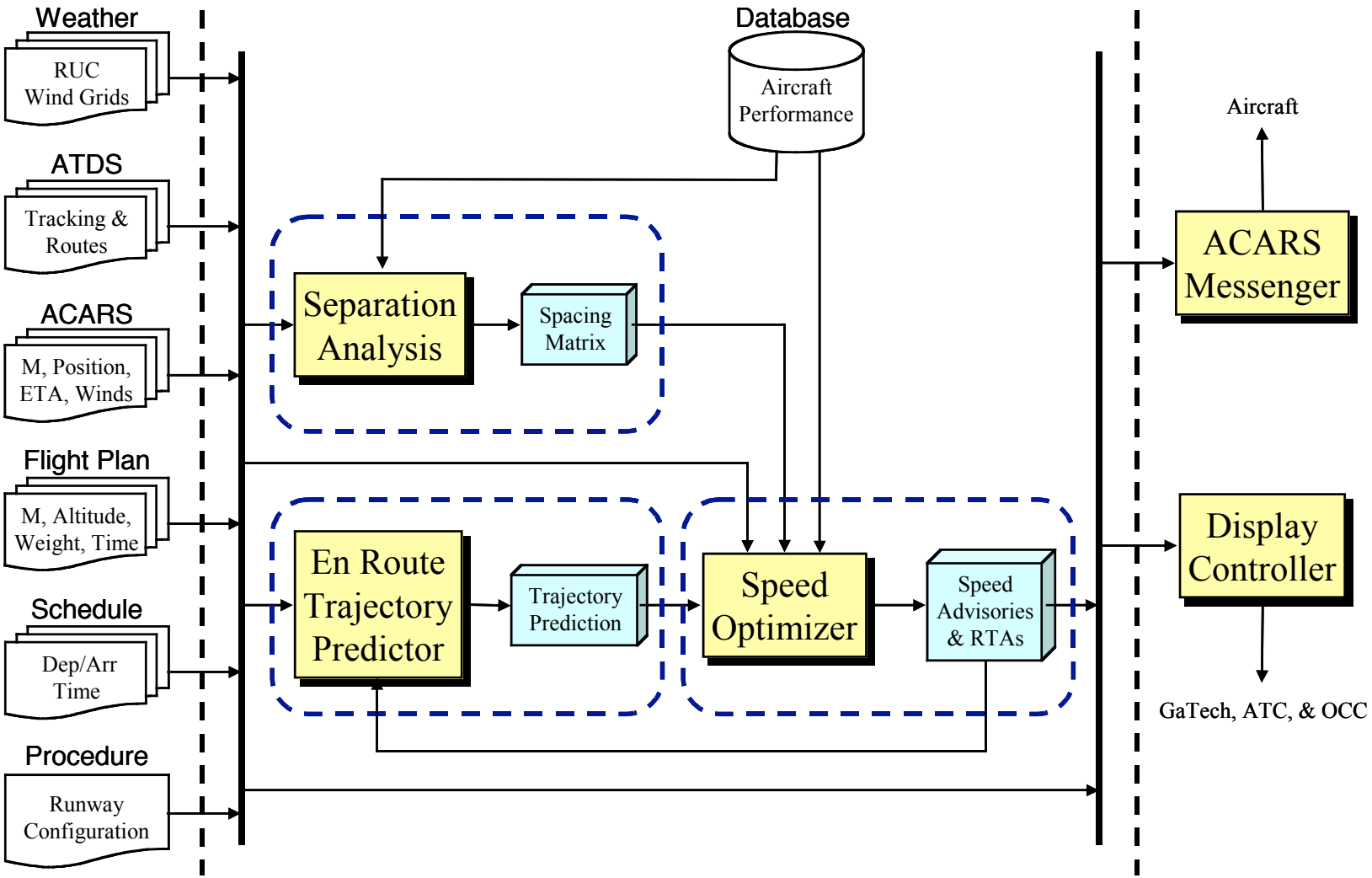
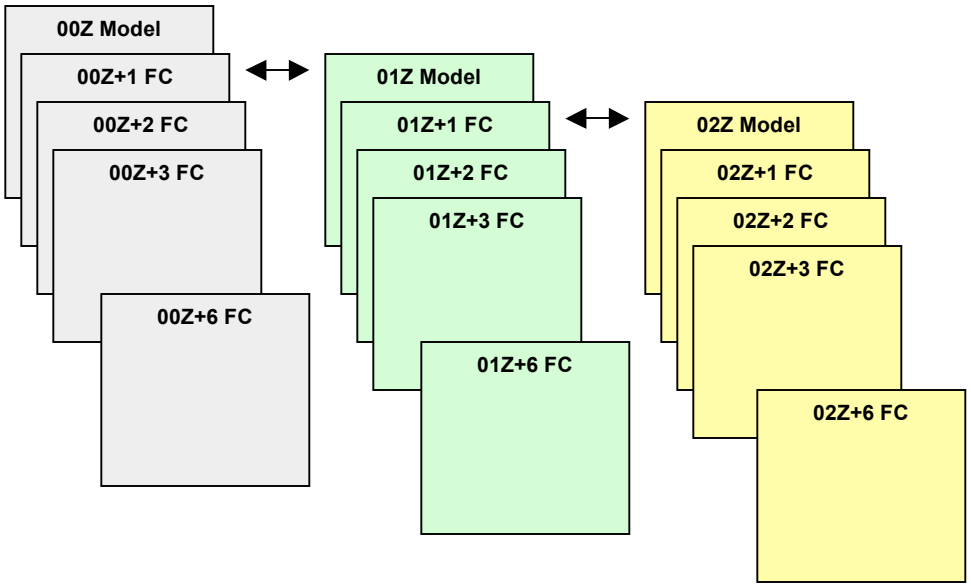
Approach


Weather
RUC
Wind Grids
ATDS
Tracking &
Routes
ACARS
M, Position,
ETA, Winds
Flight Plan
M, Altitude,
Weight, Time
Schedule
Dep/Arr
Time
Procedure
Runway
Configuration
Database
Aircraft
Performance
Separation
Analysis
Spacing
Matrix
En Route
Trajectory
Predictor
Trajectory
Prediction
Speed
Optimizer
Speed
Advisories
& RTAs
Aircraft
ACARS
Messenger
Display
Controller
GaTech, ATC, & OCC

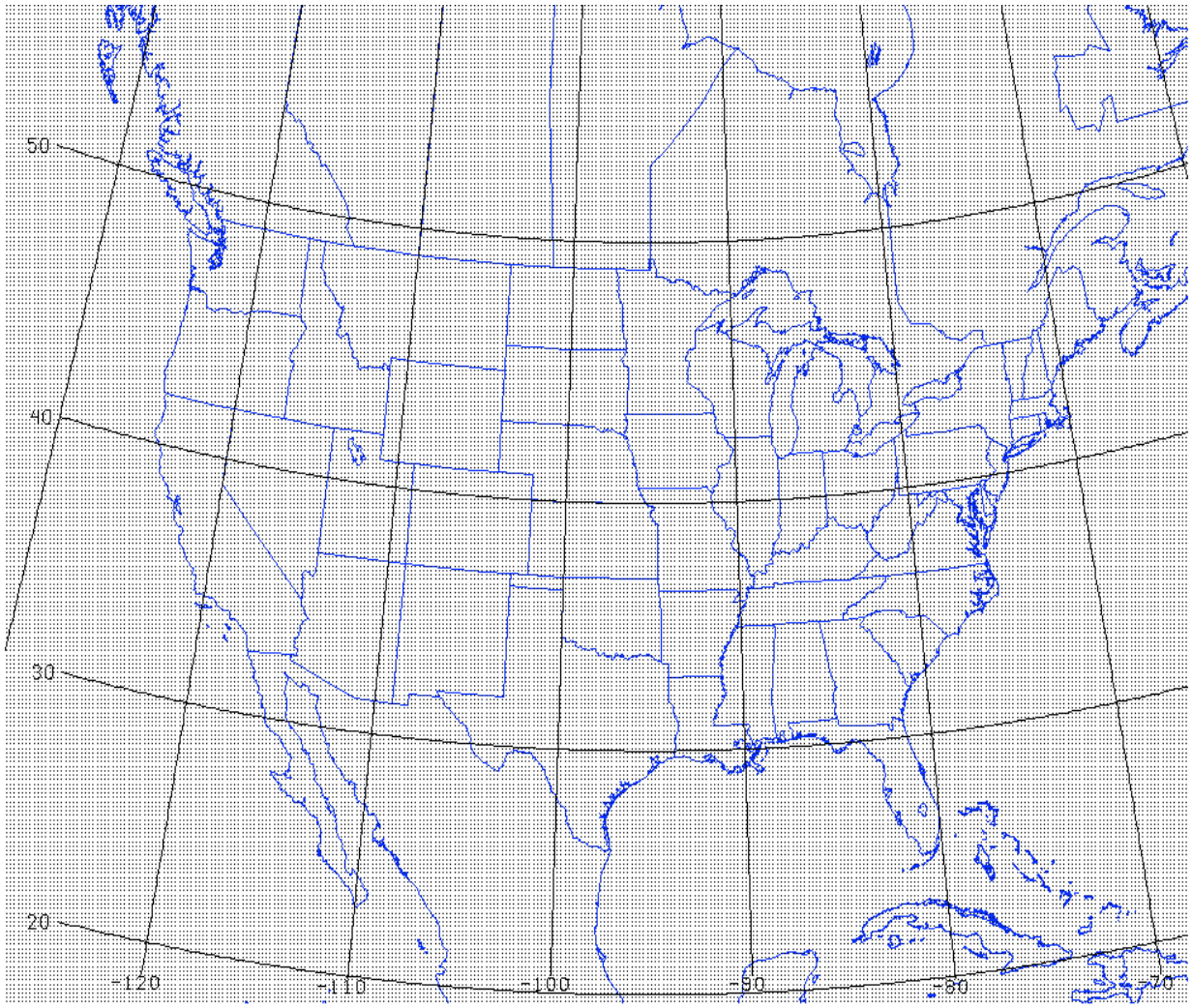
ETA Prediction Tool: RUC20

RUC20 Data

- Lateral Grid: 301x225 (20km spacing)
- Vertical Resolution: 25-hPa increments from 1000-100 hPa
- Forecast is given in 1 hr intervals for a 12 hr span every hour (only the 1hr, 2hr, 3hr, and 6 hr forecasts are available with regularity and currently archived)

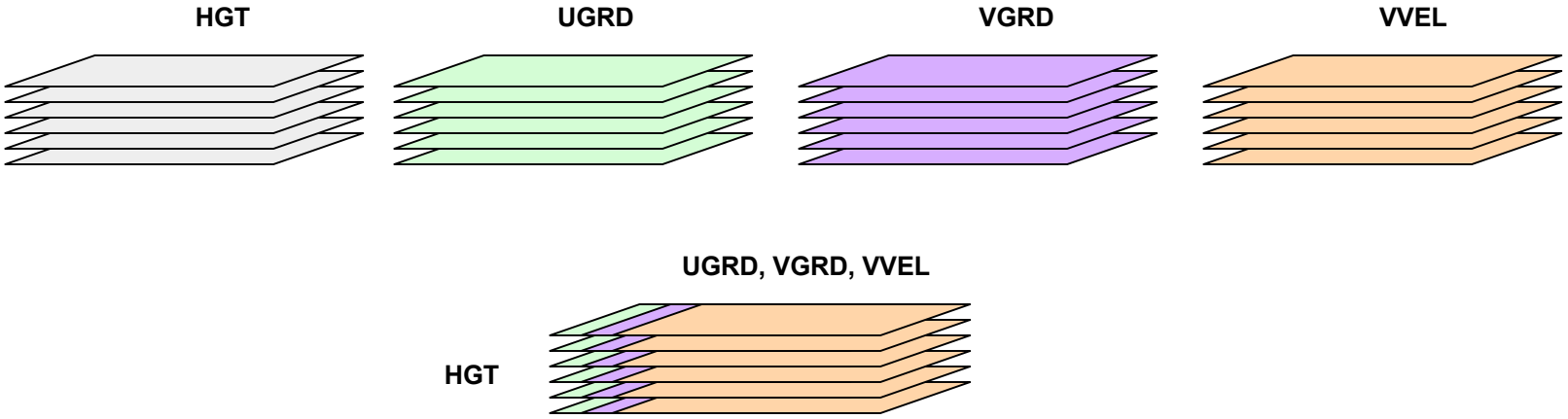


ETA Prediction Tool: RUC20 (cont'd)



ETA Prediction Tool: RUC20 (cont'd)

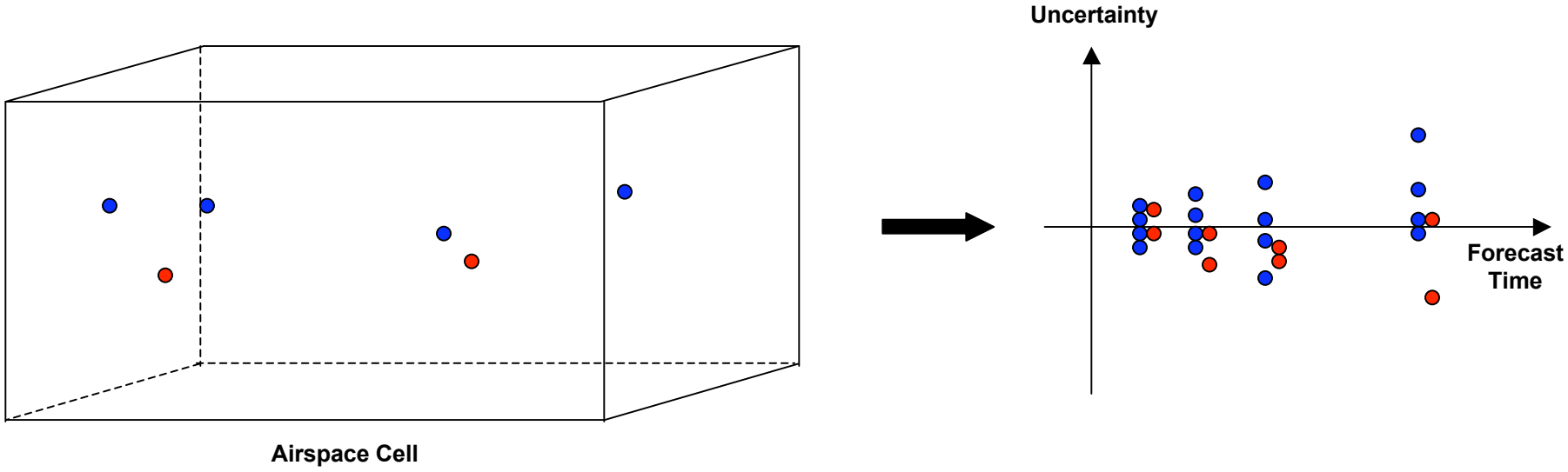
- **RUC20 Data Organization**
  - Provided as numbered "messages" organized in isobaric sheets
  - Messages must be correlated into usable data structure
  - Create sector-based structure giving Northern, Eastern, and vertical wind intensities as functions of altitude for every RUC20 grid sector



ETA Prediction Tool: Uncertainty

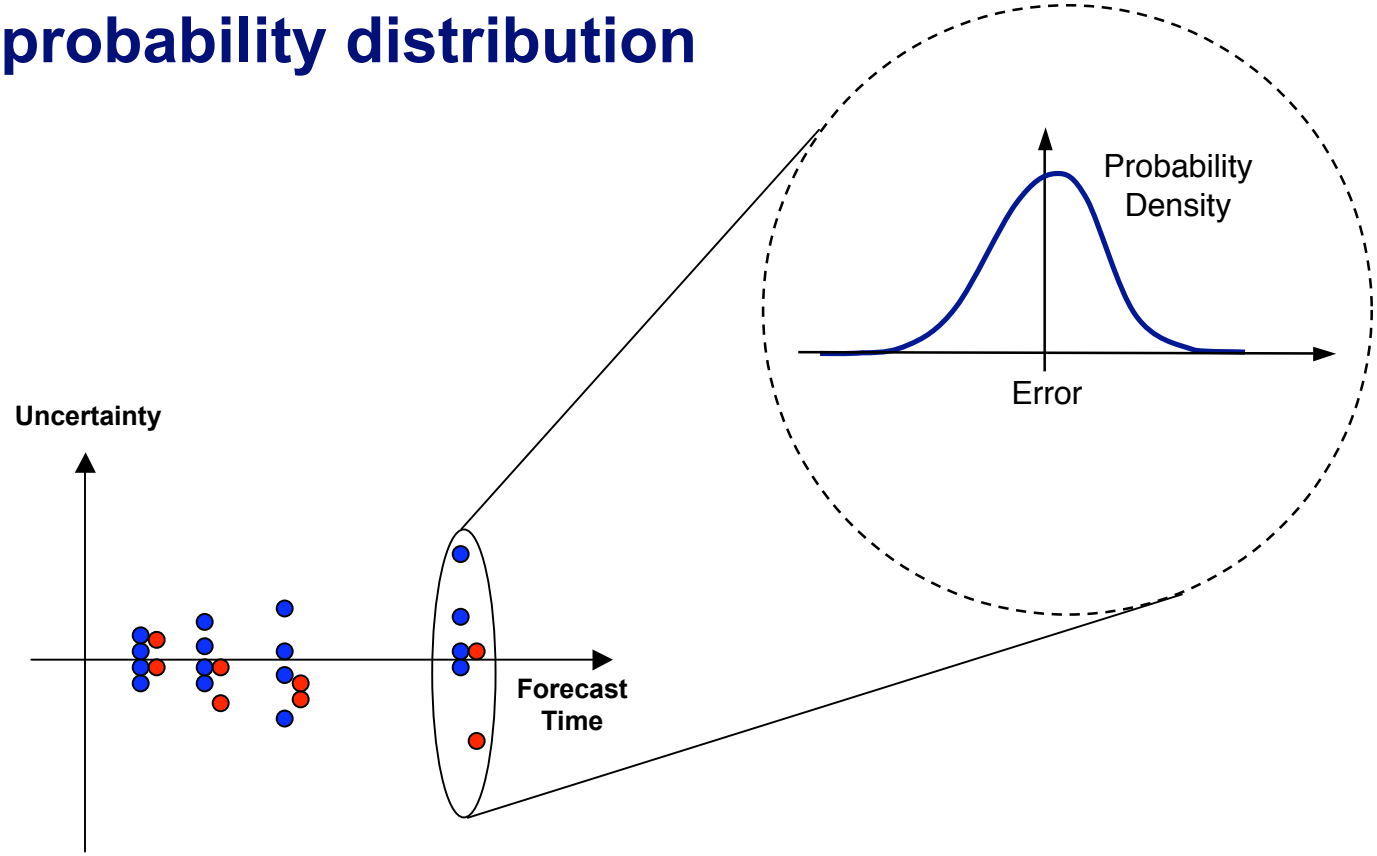
Uncertainty Model

- Compare known wind conditions from archived ACARS data to RUC wind forecasts
- Model uncertainty intensity as a function of forecast time for individual airspace cells



ETA Prediction Tool: Uncertainty (cont'd)

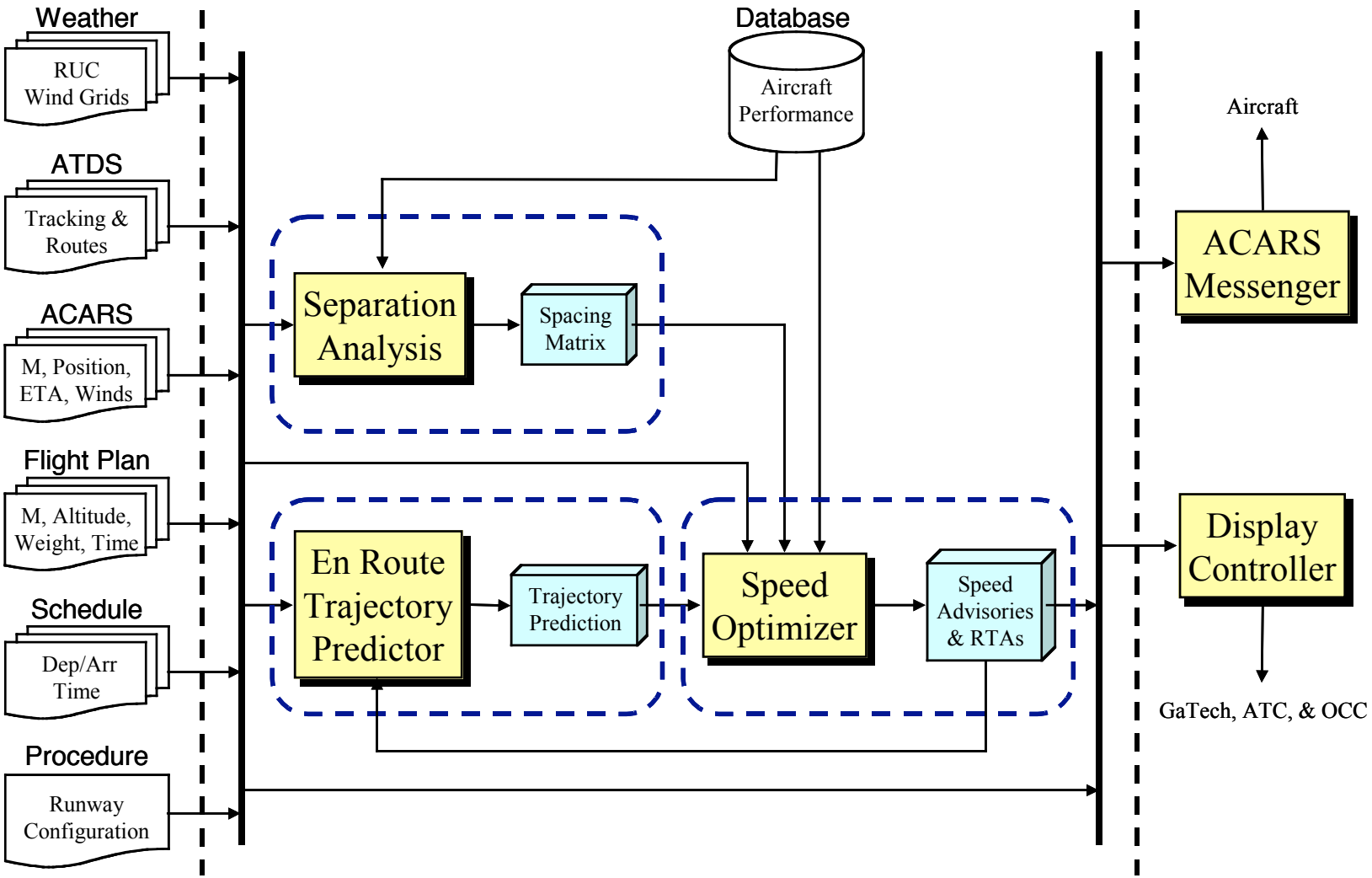
- **Aggregate effects of forecast uncertainty as a probability distribution**



ETA Prediction Tool: Uncertainty (cont'd)

- **Determine uncertainties over entire trajectory**
  - Combine uncertainties throughout the trajectory
- **Add uncertainty to "deterministic" ETA calculated using RUC winds**
- **Provide ETA distributions to speed optimizer**

Approach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Optimization: Objective Function

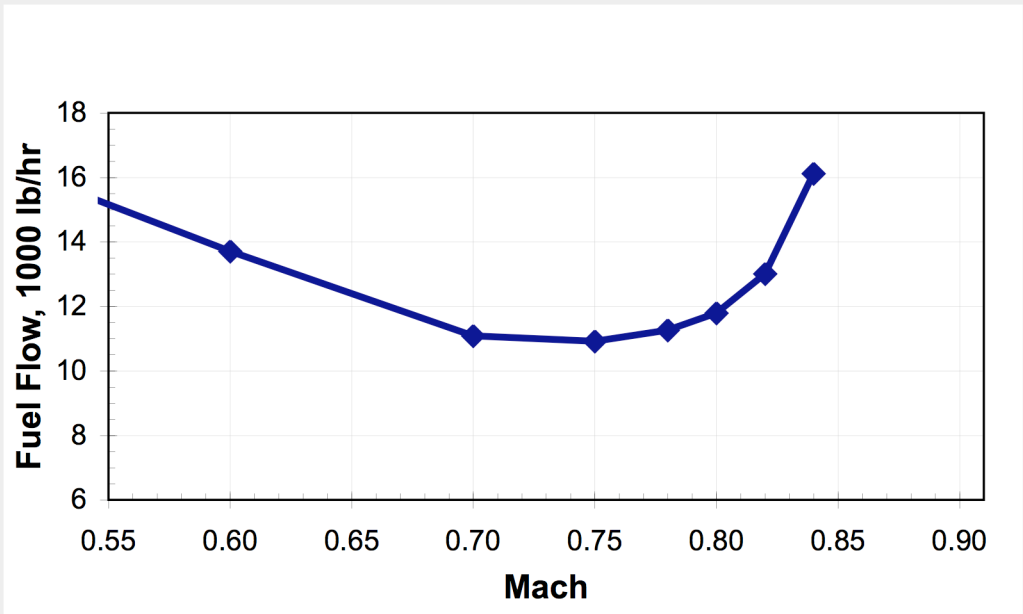
$$\min Z = \sum_{n=1}^{N} \dot{f}_i \, T_i$$

$$\dot{f}_i \geq a_{i,1} M_x + b_{i,1}$$

$$\dot{f}_i \geq a_{i,2} M_x + b_{i,2}$$

$$\vdots$$

$$\dot{f}_i \geq a_{i,m} M_x + b_{i,m}$$



Linearized fuel constraints

Optimization: Constraints

$$(t_{i+1} - \Delta t_{i+1}) - (t_i - \Delta t_{i+1}) \geq S_i$$

Separation determined by TASAT analysis

$$\delta_i \leq M|\Delta t_i|$$

$$\delta_i \geq \frac{|\Delta t_i|}{M}$$

Maximum one speed change per aircraft

$$\delta_1, \delta_2, \ldots \delta_n \text{ binary}$$

$$\sum_{j=1}^{J} \delta_i \leq j$$

Limit number of aircraft able to make a change

$$M_i + \Delta M_i \leq M_{i,\max}$$

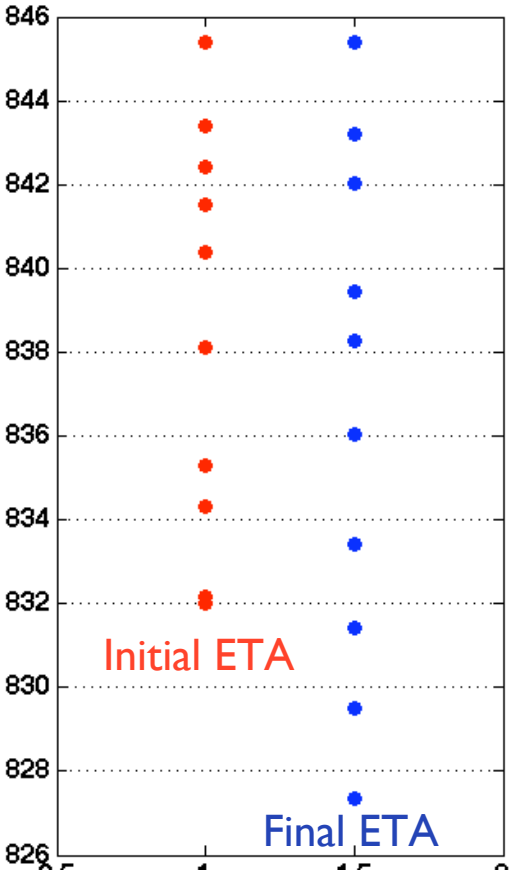
Performance limits upper Mach number

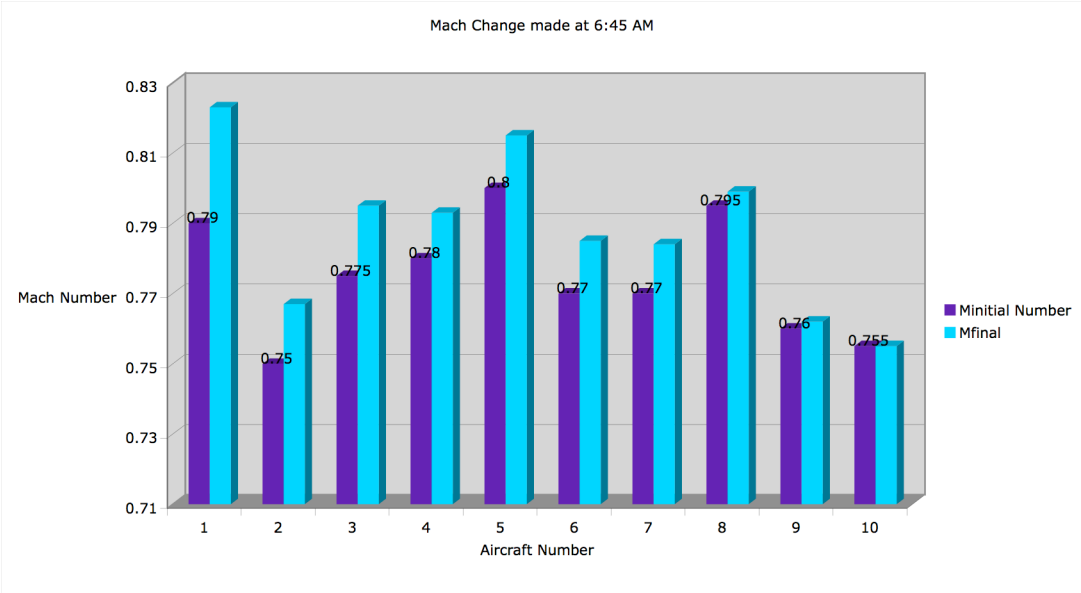
$$|\Delta M_i| \leq \Delta M_{\max}$$

Lower mach number determined by range between initial Mach and maximum Mach

Optimization: Initial Results

- **Comparison of Initial and Final Mach numbers for 10 aircraft 2 hours prior to the last aircraft arriving**





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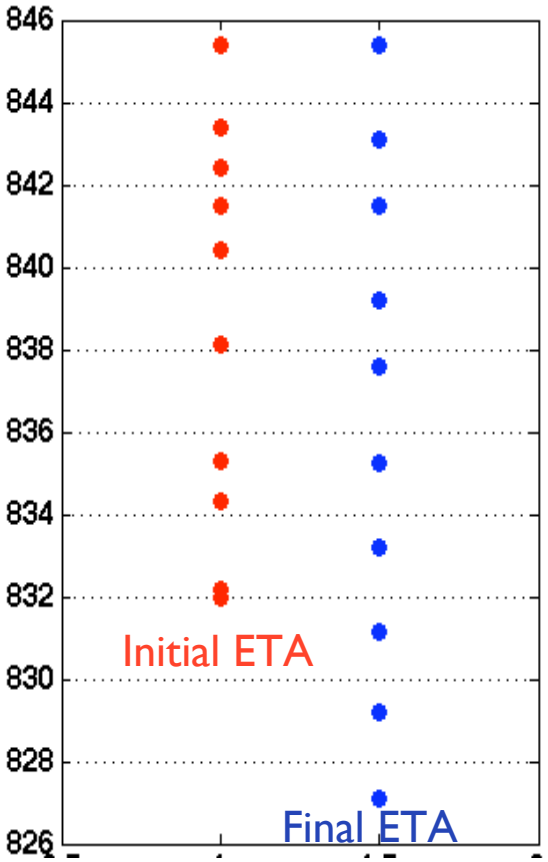

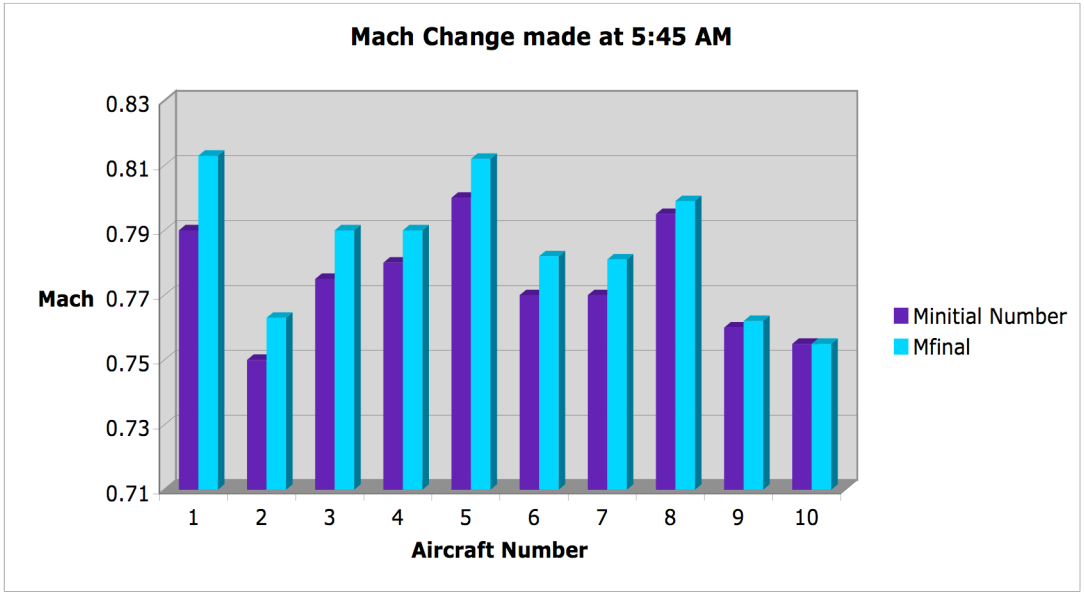

Optimization: Enhancements

- **Expand formulation to allow…**
  - Sequence change
  - Two speed changes per aircraft
  - Include wind information in calculation of final Mach number